**Designing Earth-Abundant Nanostructured Electrocatalysts for Efficient and Selective Conversion of Energy and Chemicals**

*Song JinA*

A Song Jin, Department of Chemistry, University of Wisconsin-Madison, 1101 University Ave., Madison, WI 53706, USA, e-mail: [jin@chem.wisc.edu](mailto:jin@chem.wisc.edu); group webpage: <http://jin.chem.wisc.edu/>

Due to the intermittent nature of most renewable energy sources (such as solar and wind), practical large scale renewable energy utilization demands both efficient energy conversion and large scale energy storage or alternative usage. Earth-abundant but highly active and selective electrocatalysts are needed to enable efficient and sustainable production of energy using electrocatalytic and photoelectrochemical (PEC) energy conversion. We developed earth-abundant nanoscale electrocatalysts, such as exfoliated nanosheets of MoS2 and ternary pyrite-type cobalt phosphosulfide (CoPS), for enhancing hydrogen evolution reaction (HER). The increasingly affordable renewable electricity can also drive electrocatalytic reactions to produce value-added chemicals. For example, biomass-derived molecules, such as HMF and glycerol, can be upgraded to value-added chemicals using metal oxide/hydroxide electrocatalysts. We will highlight our recent work on combining computations and experiments to demonstrate cobalt pyrite (CoS2) is both active and selective towards two-electron oxygen reduction reaction (2e- ORR) to make H2O2 in both acidic and neutral solutions. Direct electrochemical synthesis of H2O2 with high performance and selectivity in acidic solution was demonstrated to enable decentralized on-site electrochemical production of H2O2 for industrial and environmental applications, such as waste water treatment. This work reveals general mechanistic insights about selective ORR and opens up a new direction in searching for more active and selective earth-abundant 2e- ORR electrocatalysts among metal compound catalysts for efficient decentralized H2O2 production.

**References**

1. Sheng, H.; Hermes, E. D.; Yang, X.; Ying, D.; Janes, A.; Li, W.; Schmidt, J. R.; Jin, S., Electrocatalytic Production of H2O2 by Selective Oxygen Reduction Using Earth-Abundant Cobalt Pyrite (CoS2). *ACS Catalysis* **2019**, *9*, 8433-8442.
2. Liu, W.; Dang, L.; Xu, Z.; Yu, H.-Q.; Jin, S.; Huber, G. W.; Electrochemical Oxidation of 5-Hydroxymethylfurfural with NiFe Layered Double Hydroxide (LDH) Nanosheet Catalysts. *ACS Catalysis* **2018**, *8*, 5533–5541.
3. Yang, Y.; Dang, L.; Shearer, M. J.; Sheng, H.; Li, W.; Chen, J.; Xiao, P.; Zhang, Y.; Hamers, R. J.; Jin, S.; Highly Active Trimetallic NiFeCr Layered Double Hydroxide Electrocatalysts for Oxygen Evolution Reaction. *Adv. Energy Mater.* **2018**, *8*, 1703189.
4. Yin, Y.; Zhang, Y.; Gao, T.; Yao, T.; Zhang, X.; Han, J.; Wang, X.; Zhang, Z.; Xu, P.; Zhang, P.; Cao, X.; Song, B.; Jin, S.; Synergistic Phase and Disorder Engineering in 1T-MoSe2 Nanosheets for Enhanced Hydrogen-Evolution Reaction, *Adv. Mater.* **2017**, *29*, 1700311.
5. Yin, Y.; Han, J.; Zhang, Y.; Zhang, X.; Xu, P.; Yuan, Q.; Samad, L.; Wang, X.; Wang, Y.; Zhang, Z.; Zhang, P.; Cao, X.; Song, B.; Jin, S.; Contributions of Phase, Sulfur Vacancies, and Edges to the Hydrogen Evolution Reaction Catalytic Activity of Porous Molybdenum Disulfide Nanosheets. J. Am. Chem. Soc. **2016**, *138*, 7965-7972.
6. Ding, Q.; Song, B.; Xu, P.; Jin, S.; Efficient Electrocatalytic and Photoelectrochemical Hydrogen Generation Using MoS2 and Related Compounds, Chem **2016**, *1*, 699-726.
7. Cabán-Acevedo, M.; Stone, M. L.; Schmidt, J. R.; Thomas, J. G.; Ding, Q.; Chang, H.-C.; Tsai, M.-L.; He, J.-H.; Jin, S.; “Efficient Hydrogen Evolution Catalysis Using Ternary Pyrite-Type Cobalt Phosphosulphide” *Nature Materials* **2015**, *14*, 1245.